International Journal of Computing Science and Information Technology, **2014, Vol.2,Iss. 1, 11-18**
ISSN: 2278-9669, January 2014 (http://ijcsit.org)

THE ASSESSMENT AND MANAGMENT OF WATER RESOURCES IN EL-QAA PLAIN SOUTHWEST SINAI PENINSULA, EGYPT USING REMOTE SENSING TECHNIQUES

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Abstract :

The present work deals with the water resources assessment of the Quaternary aquifer system in El-Qaa Plain, Southwest Sinai Peninsula, Egypt. The area is suffering from water deficiency due to an increase in human settlements and activities. Available hydro geological data are also used for this assessment. El-Qaa plain is divided into two main blocks separated by an inferred fault which runs across Wadi Isla. The northern block includes three aquifers, while the southern block includes only one reservoir with no fresh groundwater. The fresh water quality displays a TDS range between 420 and 7403 mg/l, which increases in the summer season. A plan for water development of facilities is proposed for a better distribution and management of available water resources.

Introduction :

El-Qaa plain is the most promising Quaternary aquifer system in South Sinai. The plain is located in the south western part of the Sinai Peninsula (Figure1) and covers an area of about 3900 km2. Its maximum width from east to west is 25 km. The plain is bounded from the east by Pre-Cambrian Basement rocks, from the north by Gebel Hadahid and from the west by Gebel◌s Qabliat, Hammam Saidna Musa and the Gulf of Suez. The plain is dissected by a group of Wadis flowing to the Gulf of Suez near El-Tour City, such as wadi Gibah, Wadi Hibran, Wadi Mir, Wadi Isla, Wadi Thiman and Wadi EL-Awag.

The groundwater in the Quaternary aquifers is highly exploited to meet the water demand for irrigation and domestic use in the cities of El-Tur and Sharm El-Sheikh.

Hydrogeological Conditions :

The Quaternary sediments with variable thickness reaching up to 1000 m. are overlaying the older rock units which belong to the Tertiary, Mesozoic and Paleozoic in the western parts of the plain and to the Basement rocks in the eastern and the southern parts of the plain. The Quaternary sediments mainly consists of sand and gravel with thin clay interbeds. Hydro geologically, El-Qaa plain is divided into two sub-basins, separated by a fault passing through Wadi Isla. These sub-basins are the Northern and the Southern Sub-basins.

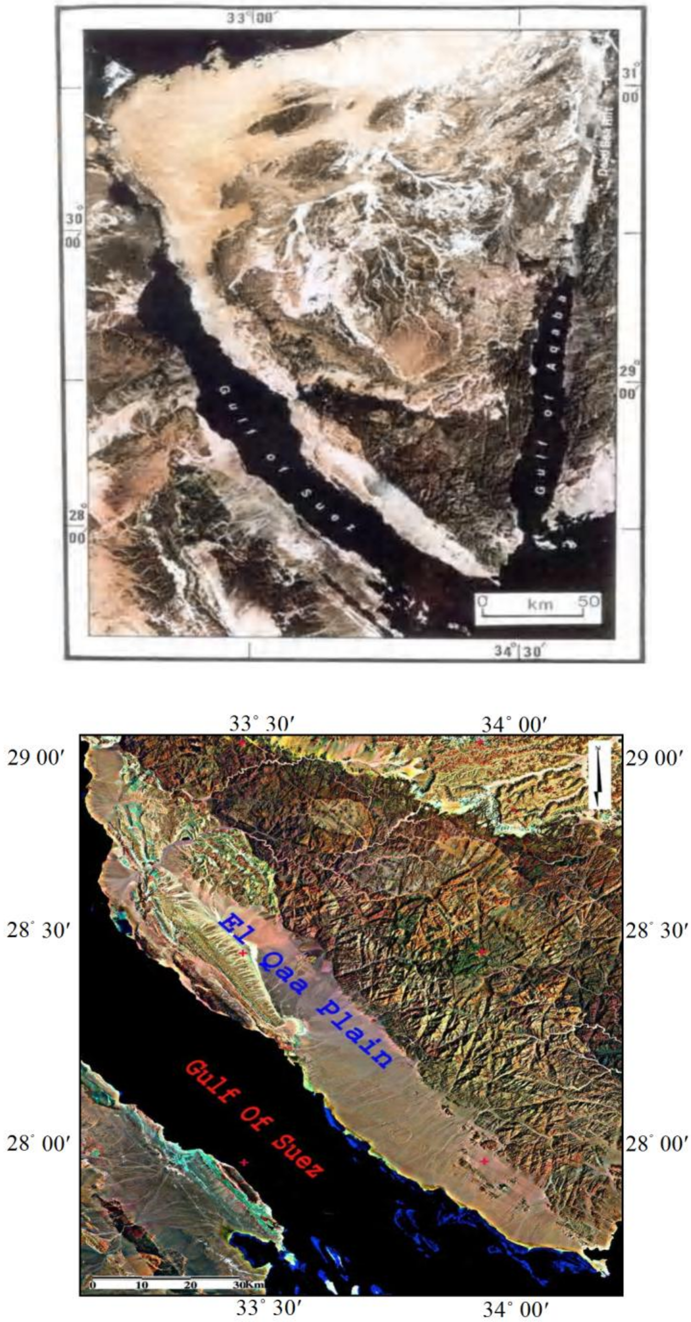


Fig. (1) : Landsat Composite showing alluvial fans along the El Qaa Plain

1. The Hydrogeological Conditions in the Northern Sub-basin :

The Quaternary deposit in the northern sub-basin consists of three aquifer systems (zones) as follows :

- The Upper Zone consists of about 100 m of gravel and sand and is thinning toward the south.
- The Middle Zone consists of about 100 m of sand and gravel with clay intercalations. It is the most promising and prospective aquifer and is highly exploited.

- The Lower Zone consists of about 200 m of sand and gravel with silt and clay interbeds.

2. Hydrogeological Conditions in the Southern Sub-basin

The aquifer consists of sands and gravel. The fresh groundwater is limited in this sector to the up stream areas of Wadi Isla and Wadi Thiman, where water is extracted from shallow wells. Some hydrogeological factors of the northern and southern sub basins are summarized on table (1).

Table (1) : Hydrogeological factors of the northern and southern sub basins

Aquifer	Yield m^3/h	Specific capacity (1/s/m)	Transmissivity m^2/day	Hydraulic Conductivity m/day
Northern aquifer	20-115	0.33-6.11	106-2150	4.6-71.6
Southern aquifer	48.6-101.5	0.53-9.23	81.2639	2.7-71.5
Southern part of El-Qaa Plain	20.3-52.0	0.08-1.07	9-52.3	0.28-5.23

Groundwater Extraction :

Most of the groundwater supply in the region is extracted from the second aquifer to met the water demand of the cities of El-Tur and Sharm El-Sheikh while a few number of wells (5 wells) are used for irrigation. The annual total extraction is about 3.44×10^6 m^3/ year.

Table (2) : The groundwater extraction was estimated by JICA, (1999).

Domestic water for El-Tur	Domestic water for sharm El-Sheikh	Irrigation	Number of Dug wells	Total m^3/day
6.000 m^3/day	1.000 m^3/day	451 m^3/day	2000	9415

Water Level :

Groundwater monitoring reveals that the groundwater level tends to decrease gradually. The annual average decrease is estimated to be 6.3 cm/year. The static water level ranges from 25 m.a.s.l at the central part of El-Qaa plain to about 5 m.a.s.l around El-Tur (Figure 2). The groundwater level in the dug wells ranges from 5.2 m.a.s.l to 13.9 m.a.s.l and decreases to 1.1 m.a.s.l south of El-Tur City (Figure 2). The gradient water level is 0.6/1000 and this means that the groundwater flows is from north to south.

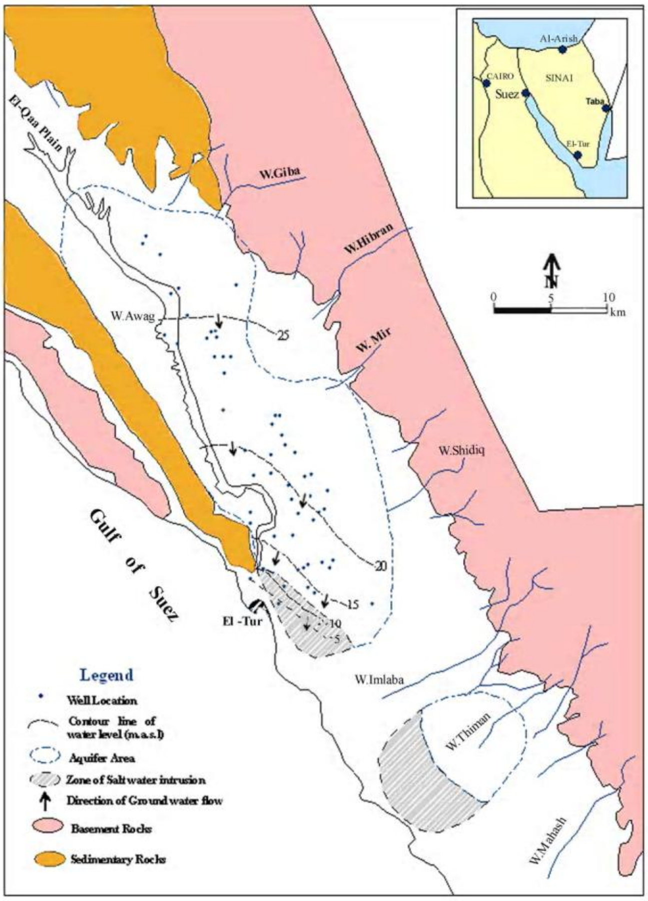


Fig. (2) : Peizometric head and Groundwater flow in El-Qaa Plain, (Modefied after JICA, 1997).

Water Quality :

The groundwater salinity increases from the northeast to the south, towards El-Tur. TDS ranges from 425 to 7403 mg/l in winter and from 452 to 10.273 mg/l in summer seasons. Figure (3) shows the TDS distribution in winter and summer seasons respectively. The salinity map showing that low salinity areas less than 500 mg/l are located in the northern sector of El-Qaa plain about 15 km north of El-Tur. High TDS contents are a supplied from Mesozoic sedimentary rocks.

Groundwater storage :

The aquifers mainly consists of sand and gravel with thin clay interbeds. This effective porosity is estimated as 0.15.

The saturated volume for the aquifer is approximately 83.6 x 10^9 m^3. According to JICA, 1999, the total groundwater storage was estimated at 12.5 X 10^9 m^3 in the northern sector.

On the other hand, the increase of groundwater storage during the period from 1994 to 1996 was calculated as 36.6X10^6 m^3, while the annual extraction was estimated to be 304X10^6 m^3 according to the rainfall precipitation recorded from St Catherine meteorological station.

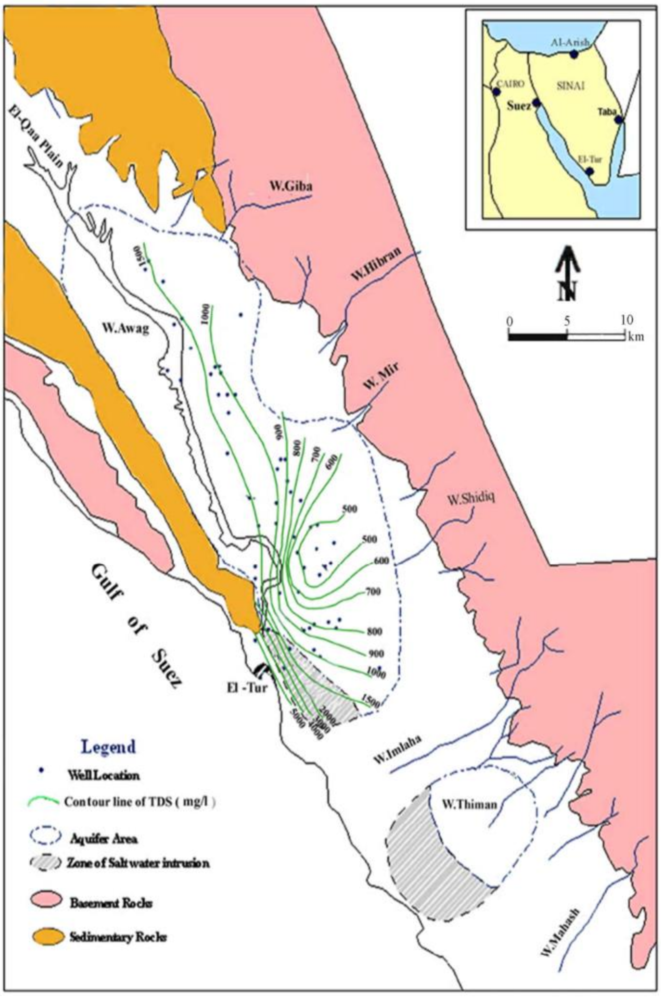


Fig. (3) : Iso-Salinity Contour Map of Groundwater in El-Qaa Plain, (Modefied after JICA, 1997).

Surface Water Assessment :

The study area is surrounded from the south west by the large body of saline water of the Gulf of Suez and from the east by the high rough crystalline basement rocks exposures. There are no natural streams flowing through the area. The study area categorized as a dry region. The annual rainfall is at a minimum and falls during the winter season from October to May. Figure (4) is an Isohyetal map for the Sinai Peninsula.

Due to the rough topography, geomorphology and geology of South Sinai, a small amount of rainfall with high intensity in a short period of time causes flash floods. The area under consideration is dissected into 10 catchments areas. Although rainfall is scarce, the area is very famous for its flash floods with high velocity, which causes damages to the infrastructures.

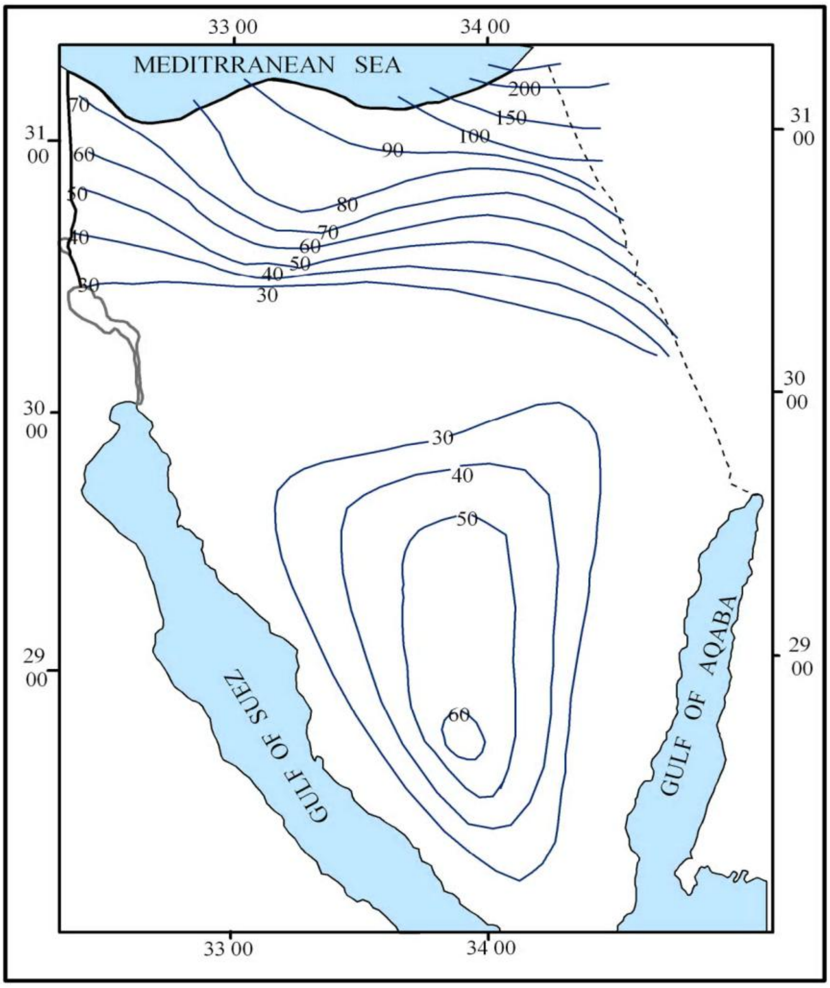


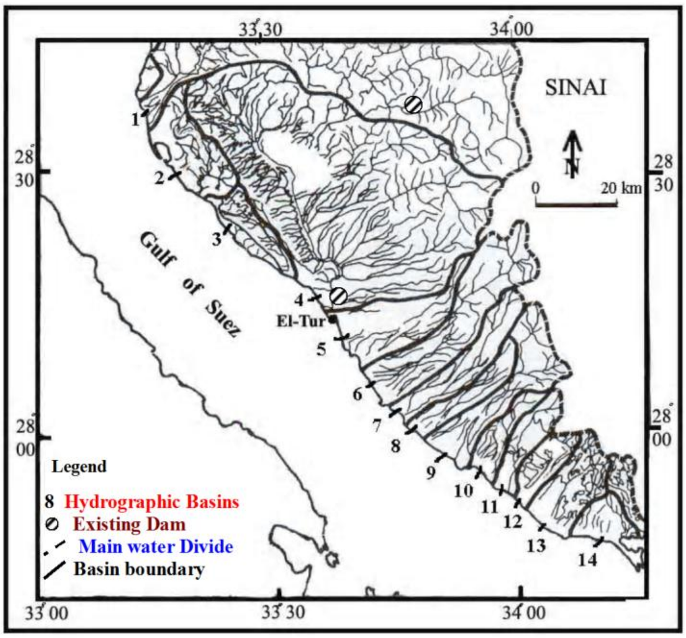
Fig. (4) : Distribution of the mean annual precipitation in Sinai. (After RIWR,1988)

Risk Assessment of Flash Flood :

El-Qaa plain as a whole does not have a major flash flood problem. The surface flows from El-Qaa plain carries a lot of sediments. The risky zone is at the point where Wadi El-Awag crosses the highway near El-Tur City.

Tectonically the study area is divided into two longitudinal parts parallel to the general structural trend of the Gulf of Suez. One of these areas is a wide longitudinal depression (El-Qaa plain) close to the Gulf and represents the downthrown side of the rift as a part of its structural and depositional province. The other parallel area is the upthrown side of the rift from Gebal Qabeliat and Gebal Araba. The main courses of all the wadis are narrow and perpendicular to the Gulf. The vast area of El-Qaa plain is braided with parallel drainage between the Gulf and the rocky areas. These braided drainage segments are also perpendicular to the Gulf.

The highly dangerous sites include ; El Tor City and the various touristic villages, built over the alluvial fan of Wadi El Aawag (Yehia et al. 2000), the Ras Sudr- El Tor Road (which crossed by Wadis Lahata), the El Tor-Ras Mohamed Road (which is crossed by W. Wardan, Abu Rudies-El Tor Road, where it is crossed by Wadis Sidri and Baba), the Abu Rudies- Belayim Road (which is crossed by the alluvial fan of W. Feiran) and the Abu Rudies-El Tor Road (which is crossed by Wadis Feiran and El Aawag) (Figure 5). Table (3), Summarize the runoff and recharge in some wadis, calculated value according to (JICA, 1999).



Key to Hydrographic Basins Identification

1 Wadi Feiran
2 Wadi Belaeem
3 Wadi Araba
4 Wadi El-Awag
5 Wadi Emlaha
6 Wadi Sala
7 Wadi Garf
8 Wadi Merikh
9 Wadi Thiman
10 Wadi Umm Saad
11 Wadi El-Mahash
12 Wadi El-Latehia
13 Wadi El-Ate El-Gharbi
14 Wadi Khashib

Fig. (5) : Hydrographic Basins and Existing Dam site

Table (3) : The runoff and recharge in some wadis, calculated value according to JICA (1999).

No	Wadi Name	Area (km^2)	Total Rainfall ($1000m^3$)/year	Runoff (m^3 / year)	Recharge (m^3 /year)	Runoff & Re-charge JICA,1999
1	**Al-Awag**	1934	25.142	3.529.550	11.942.450	15.472.000
2	**Emlaha**	236	2.596	215.350	1.200.650	1.416.000
3	**Sala**	386	3.860	366.314	1.563.686	1.930.000
4	**Thiman**	307	2.763	280.138	947.863	1.228.001
5	**El-Mahash**	318	2.544	290.175	663.825	954.000
6	**El-Latehia**	134	938	122.275	145.725	268.000
7	**El-Ate El-Garbi**	101	707	92.163	109.838	202.001

Water Development Plans :

The proposed plain should supply 5.300 m^3 / day to El-Tur City. The water well fields should be located 17 km northeast of the City of El-Tor, while the distribution water reservoir for the distribution of water should be located 8 km northeast of El-Tor and be positioned in order to enable the transfer of water by gravity to El-Tor. Figure (6), shows the sketch of longitudinal profile for conveyance pipe-line

Fig. (6) : Sketch of longitudinal profile for conveyance pipe-line

Conclusion :

The study reveals that because of limited recharge of the groundwater aquifers, the present water balance could meet the water demand of El-Tor city for about only 10 years, without water deterioration due to the intrusion of salt water in the aquifer, which may come from the saline water body found below the fresh water aquifer (up-coning). Such deterioration usually flows over pumping and over extraction .

Therefore, it is necessary to increase the water resources of the region through addition of Nile Water or by installing desalination units

Recommendations:

- Establishment of a groundwater monitoring system to avoid excessive groundwater extraction.
- Wastewater treatment and disposal should be taken into account.
- Detailed study aquifers geometry at different depth and levels should be carried out to increase the water resources supply from new aquifers.
- Establishment different hydrological structures such as dams and water breaker, along the active wadis to minimize the risk of flash floods and increase the recharge to the groundwater storage.

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